MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

A PARAMETRIC DESIGN STUDY OF InGaAs MICRO-THERMOPHOTOVOLTAIC CELLS COUPLED WITH VARIOUS EMITTERS AT NEAR AND FAR SPACING

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A preliminary design study was conducted to determine the effect of various parameters on the performance of InGaAs thermophotovoltaic devices. The electrical power output density of the device, and the device efficiency were analyzed by considering different emitter temperatures and materials, various receiver band gap levels, and a range of gap spacings between emitter and receiver. Sub-micron spacing devices are denoted as micro-thermophotovoltaic devices (MTPV), while greater than micron gap spacing devices are known as thermophotovoltaic devices (TPV). The far spacing model, or spacing of magnitude much greater than the wavelength of the emitted radiation, was based on classical radiative heat transfer equations and standard photovoltaic cell equations. The close spacing model, or spacing with a magnitude on the order of magnitude of the wavelength of the emitted radiation, was based on the fluctuation-dissipation theorem whereby the energy is transmitted by evanescent waves between the emitter and receiver. The analytical models used realistic property values for both the receiver and the emitter, and the results show the superiority of tungsten as an emitter for the far spacing case. At close spacing, silicon carbide exceeds the performance of the refractory metals down to the spacing limited by current technology. However, if spacing control technology advances and smaller gaps become feasible, rhenium emitter devices could provide a significant increase in power density, and with similar efficiencies as the far spacing case.

KEYWORDS: Microthermophotovoltaic Device, Thermophotovoltaic Cell, Static Direct Energy Conversion, InGaAs Receiver, Refractory Metal Emitter, Silicon Carbide Emitter

COUPLED STABILITY ANALYSIS OF CLOSE PROXIMITY SHIP TOWING

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The scope of this thesis is to study the stability of two ships in close proximity towing. Unlike previous studies in the past, the lateral dynamics of both ships are included in the formulation. The equations of motion of the system consist of the sway and yaw motions of the two ships and a control law for the leading ship. An eigenvalue stability analysis of the coupled system confirms the results that are obtained through numerical simulations. It is shown that it is possible for the system to be unstable even though the classical criteria for towing stability are satisfied. A series of parametric studies is conducted in order to analyze the sensitivity of the system for different towline lengths, tension, and control time constant.

KEYWORDS: Towing, Directional Stability

REDUCTION OF MARINE GAS TURBINE EXHAUST INFRARED SIGNATURE

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A preliminary conceptual study was conducted to determine a wide range of possible methods of reducing the infrared radiation signature of the exhaust plume from a gas turbine powered ship. The concepts fell into three general categories; reducing exhaust gas temperature, using obscurants, and shaping of the exhaust plume. Two of the concepts, an in-line heat exchanger and a Steam Augmented Signature Suppressing Eductor (SASSE), were analyzed and predictions of the reduction in exhaust plume infrared radiation signature were made. A set of rudimentary design characteristics was developed for an in-line heat exchanger, proving the feasibility and capabilities of a heat exchanger. An analytical model was developed to predict the effect of a SASSE on a simple exhaust eductor system. The SASSE model predicted a significant reduction in the final exit temperature of the exhaust gas.

KEYWORDS: Modeling and Simulation, Gas Turbine Exhaust, Eductors, Mixing Ejectors

WEAPONEERING SMALL BOATS

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Using statistical methods, weaponeering combines the targets vulnerability, type of weapon used, weapon ballistic trajectories, weapon delivery errors, probability of kill, and a myriad of other factors and determines a probability that the battlefield planners goals will be met. Based on this statistical information the battlefield planner can make a decision on the best way to implement a battle plan.

Based on statistical models this thesis develops an analysis tool using Microsoft Excel that explores the effects of dropping cluster munitions on fast highly maneuverable small boats to determine the probability of damage to the small boat and compares the results with the effects of dropping a unitary fragmentation weapon against the same target.

KEYWORDS: Weaponeering, Single Sortie Probability of Damage, Lethal Area

STUDY OF PROCESSING AND MICROSTRUCTURE OF A SUPERPLASTIC 5083 ALUMINUM ALLOY

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Orientation Imaging Microscopy (OIM) methods were applied to the analysis of the microstructure and microtexture as well as the deformation and failure modes of superplastic AA5083 aluminum alloys. Annealing of a cold-rolled AA5083 material at 450ºC resulted in the formation of equiaxed grains approximately 7μm – 8μm in size. Random grain-to-grain misorientations were consistent with particle-stimulated nucleation of recrystallization during processing for superplasticity. Such a microstructure is necessary for superplasticity but mechanical property data indicated only moderate ductility and failure by cavity formation and linkage. This investigation then employed OIM methods to identify the misorientations of boundaries prone to cavitation and determine the role of such boundaries in failure of these materials during elevated temperature deformation.

KEYWORDS: Orientation Imaging Microscopy, Superplasticity, Recrystallization, Deformation Mechanisms, Grain Boundary Sliding, Dislocation Creep, Cavitation

TARGET ACQUISITION MODEL FOR MILITARY OPERATIONS IN AN URBAN TERRAIN (MOUT)

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When conducting military operations, it is important for analysts and military planners to have accurate tools to use for mission planning and war game analysis while missions are in the planning stage. Target acquisition is an important step in making this process as accurate as possible.

The focus of this paper is to model the ability of soldiers in MOUT environments to accurately distinguish between targets and non-targets in the visual and thermal spectrum. By using modeling tools and frequency domain vision theory, it is possible to predict a soldier's ability to make this distinction.

After extensive research, the ACQUIRE model was chosen as the most practical choice to use in this application. However, the theory behind the ACQUIRE model development was coded into a MS-EXCEL spreadsheet for ease of use. Once coded and validated, the ACQUIRE model was used to further analyze results published by Night Vision and Electronics Security Directorate in 1991.

It was found that the ACQUIRE model was very accurate in predicting ranges to the objects that human targets were carrying. This may be a more accurate method of determining the actual threat of a potential target. However, more study that is experimental is needed to verify that theory.

KEYWORDS: MOUT, Urban Warfare, Target Acquisition

ARIES NAVIGATION ACCURACY AND TRACK FOLLOWING

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One of the greatest challenges associated with the Autonomous Underwater Vehicle (AUV) is reliability, accuracy, and the high precision navigation system for its submerged operations. Data collected for later analysis can be meaningful if, and only if, the precise location of the vehicle is known at the time the information is recorded. A reliable AUV must be able to determine its global position in the absence of external transmitting devices. Dead reckoning is unreliable because of current conditions and random errors in the velocity measurement that can be integrated and propagated in position calculations for long distance submerged travel. The alternative is the optimal integration of all available organic vehicle sensors to determine vehicle position. This requires the Kalman filtering method which merges all available vehicle sensors to estimate position. The AUV *ARIES* was operated in the Azores from August 10-12, 2001. All information were recorded and transferred into several files for all the mission runs during the exercise. This thesis investigated the accuracy of the Kalman filter navigation system during those runs. The thesis also examines the actual vehicle tracks during the experiment with both the design tracks and the model prediction tracks built using a simulation of the vehicle track following behavior.

KEYWORDS: *ARIES* Navigation, Track Following

A DESIGN PROCEDURE FOR SEAKEEPING ANALYSIS OF CLOSE PROXIMITY SHIP TOWING

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The purpose of this thesis is to develop an efficient analysis and design procedure for assessing the seakeeping behavior of surface ships in close proximity towing. The problem is formulated by using the heave and pitch equations of motion in regular waves. The vertical plane relative motions between the trailing and the leading ships are matched through the speed-resistance characteristics of the trailing ship. A sea state degradation factor is introduced. This factor characterizes the expected seakeeping performance penalty resulting from the connection. A series of parametric studies is conducted for various geometric properties and environmental characteristics. The results can be used to evaluate the response of the system and provide insight into parameter selection for motion minimization.

KEYWORDS: Slice, Kaimalino, Seakeeping, Swath, RAO, Speed Polar Plot

MULTI-SCALE ANALYSIS OF A 2/2-TWILL WOVEN FABRIC COMPOSITE

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A micro-mechanical unit-cell model was developed for 2/2-twill woven fabric composites. A multi-scale bi-directional micro/macro-mechanical analysis technique was applied to the model in an effort to estimate effective material properties of 2/2-twill composites and decompose the effective stresses (strains) of the woven fabric composite into the stresses (strains) of the tows. When this unit-cell model is incorporated into the multi-scale analysis by combining with previously developed modules, the residual strength and stiffness of a laminated structure made of 2/2-twill woven fabric composites can be predicted along with damage progression in the structure. Damage is described at the basic material units of the composite structure, the fibers and matrix. The unit-cell model and the multi-scale analysis were validated by comparing their predicted results to available data in open literature and data obtained from a finite element models.

KEYWORDS: Multilevel Technique, Woven Fabric Composite, 2/2-twill Composite, Microanalysis, Macroanalysis

A CHARACTERIZATION OF SWAY FORCES INDUCED BY CLOSE PROXIMITY SHIP TOWING

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The scope of this thesis is to characterize the connection forces in the horizontal plane of surface ships in close proximity towing in waves. Strip theory calculations are used in order to predict the hydrodynamic coefficients and wave exciting forces and moments in sway and yaw. The resistance-speed characteristics of the leading ship are used to provide the matching condition between the two ships. The two-parameter Bretschneider Spectrum is used to model the sea environment. Results are presented in terms of speed and sea state polar plots. An extensive set of parametric studies is presented in regular waves as well as in a wide variety of sea states.

KEYWORDS: Slice, Kaimalino, Seakeeping, Swath, Bretschneider, Pierson-Moskowitch